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EXPERIMENTS

CONCERNING THE

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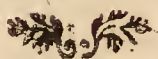
O F

POINTED and BLUNTED RODS,

In fecuring BUILDINGS againft the STROKE of
LIGHTNING.

By WILLIAM HENLEY, F.R.S.

Read at the ROYAL SOCIETY DECEMBER 16, 1773.



L O N D O N,

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EXPERIMENTS

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*Experiments concerning the different Efficacy
of pointed and blunted Rods, in securing
Buildings against the Stroke of Light-
ning.*

FROM an accident which lately happened to the chapel in Tottenham-court road, where a poor man was killed, an account of which I had the honour of presenting to the Royal Society, the Gentlemen, who have the care of that building, were desirous of erecting a proper conductor, to prevent such accidents in future; which was done accordingly under my direction, except three points at the top, to which I rather incline to prefer a single one. On this occasion, I was willing to obtain the best information I could, upon the question, *whether the preference be due to points or knobs, for the termination of conductors*; for which purpose, I made the following experiments.

EXPERIMENT I.

I placed two of Mr. CANTON's electrometers, A. and B. [See PLATE, Fig. 1.] insulated, upon stands
A. 2. of

of sealing-wax, about seven inches asunder, and as many from the end of a prime conductor, which was eighteen inches long, and one inch and an half diameter; and had a ball, at each end, two inches and a half diameter: the diameter of the electrical globe being nine inches. On the top of the box A, I placed a wire, projecting three inches from the end of it, and terminated by a ball three quarters of an inch in diameter. On the top of the box B, I placed a sharp pointed wire, projecting also three inches from its end. The knob and point were now exactly at the same distance, namely, seven inches, from the end of the conductor. Then, giving the winch five or six turns, the light cork balls, hanging from the box A, were repelled to the distance of one inch from each other; but those hanging from the box B, separated full two inches. Then touching the prime conductor with a finger, the balls at A closed, while those at B remained a full inch asunder. From this experiment, I think it seems evident, how much better adapted a sharp point is, to draw off lightning, than a knob of three quarters of an inch in diameter; and, consequently, how much more likely to cause it to pass in that conductor, to which it is affixed, rather than in any other part of the building, where it might occasion much damage, as well as endanger the lives of those, who might happen to be in it. The following experiments seem to make still more strongly in favour of the same conclusion.

EXPERIMENT II.

I affixed, to the top of a glass-stand, a wire, three eighths of an inch in diameter, terminated, at one end, by a ball, three quarters of an inch in diameter; and, at the other end, by a very sharp point. see Fig. 2. Round the middle of this wire, I hung a chain twelve inches long. I then charged a bottle containing one hundred square inches of coated surface, and, connecting the chain with the coating of the bottle, I brought the knob of it, very gently, towards the ball on the insulated wire, that I might observe precisely, at what distance it would be discharged upon it; which I found to happen constantly, at the distance of half an inch, with a loud and full explosion. Then, re-charging the bottle, I brought the knob, in the same gradual manner, towards the point of the insulated wire, to try also, at what distance that would be struck; but this, in many trials, never happened at all. The point, being approached in this gradual manner, always drew off the charge imperceptibly, leaving scarce a spark in the bottle.

EXPERIMENT III.

I had now recourse to the apparatus known, to electricians, by the name of the *thunder-house* which I thought a nearer resemblance of the operations of nature, on these occasions. Having connected a jar, containing five hundred and nine square inches of coated surface, with my prime
con-

conductor, see Fig. 3, I observed, that, if it was so charged, as to raise the index of my electrometer to sixty degrees, by bringing the ball, on the wire of the thunder-house, to half an inch distance from that connected with the prime conductor, the jar would be discharged, and the piece in the thunder-house thrown out to a considerable distance. Using a pointed wire, for a conductor to the thunder-house, instead of the knob, as in the former experiment, the charge being the same, the jar was discharged silently, though suddenly; and the piece was not thrown out of the thunder-house.

EXPERIMENT IV.

Having made a double circuit to the thunder-house, the first by the knob, the second by a sharp pointed wire, at one inch and a quarter distance from each other, but of exactly the same height, see Fig. 4. the charge being the same; although the knob was brought first under that connected with the prime conductor, which was raised half an inch above it, and followed by the point, at one and a quarter inch distance, yet no explosion could fall upon the knob; the point drew off all the charge silently; and the piece in the thunder-house remained unmoved.

EXPERIMENT V.

Having insulated the jar, and connected, by chains, with the external coating, on one side, a knob, and, on the other side, a sharp-pointed wire,

wire, both being insulated, and standing five inches from each other, see Fig. 5, I placed a large copper ball, C, eight inches in diameter (insulated also) so as to stand exactly at half an inch distance both from the knob and the point. The jar being fully charged, I delivered it upon the copper-ball by my discharging rod, whence it leaped to the knob A, which was three quarters of an inch in diameter, and the jar was discharged by a loud and full explosion, and the chain was very luminous.

These experiments were made in the presence of Mr. BELL, a very ingenious electrician, whose province it was to be particularly attentive to the phenomena, and he could perceive no light upon the chain, which connected the pointed wire B, with the coating of the jar.

EXPERIMENT VI.

I insulated my three largest jars, containing together about sixteen square feet of coated surface. From the bottom of these jars projected a wire, terminated by a ball, three quarters of an inch in diameter; and, at the distance of one inch and an half from it, I placed the insulated ball C. Fig. 6, on which I brought down the charge of the three jars, by my discharging rod; which leaped from thence to the ball in contact with the jars, and discharged them, by a loud and full explosion; but the same thing did not happen, if I removed the insulated ball only one eighth of an inch further from the other. I then removed the wire, which
was

was terminated by the ball, from the bottom of the jars ; and placed another in its stead, of the same length and diameter, but very nicely tapered to a point, as all mine are. Then, placing the insulated ball, C, one inch from the point, I brought down the charge of the three jars, as before, which flew upon the point, and melted it a little. The jars were discharged with a loud and full explosion. But having removed the ball C, to the distance of one inch and an eighth from the point, the charge could not strike it ; though much of it was presently drawn off silently, by the point, as appeared by the falling of the index of the electrometer.

From this experiment, I think it seems somewhat more than probable, that a conductor terminated by a ball, of three quarters of an inch in diameter, would be in danger of a stroke, from an highly electrified cloud, at a much greater distance, than another with a sharp termination. Indeed I cannot help remarking, how very improbable it appears to me, that a sharp pointed conductor should, at any time, invite, or solicit, a stroke of lightning. Imagine, if you please, that a large cloud is, by the force of the wind, driven violently towards such a point, and actually strikes upon it ; yet, as the point would act *as such*, at somewhat more than the striking distance, it seems probable, that part of the electricity of the cloud would be drawn off silently, before the actual stroke could be made ; and the stroke itself might thereby, perhaps, be a little lessened.

I shall

I shall here insert what seems to afford a sufficient proof of the truth of this reasoning.

Extract of a letter from Captain RICHARD NAIRNE, of the Generous Friends, dated Montreal, June 24, 1773, to Mr. THOMAS MARSHAM, in the Borough.

“ I shall make every observation I can, for the
 “ good of electricity, and the satisfaction of my
 “ friend Mr. HENLEY. I put up a longer top-
 “ gallant-mast, the day I arrived at Quebeck. The
 “ conductor, by this means, became too short;
 “ and my mate still let it hang, without making
 “ any addition to it. They had a severe thunder
 “ storm that night; but think how pleased I was
 “ to find, that, from the wetness of the ship’s
 “ sides, the electricity passed into the water,
 “ without the least injury to the ship; but the
 “ spark on the point of the conductor, which was
 “ very sharp, was so lucid, that my people were
 “ very much frightened.”

Since I received this account of Mr. NAIRNE’s observation, I have been favoured with the following remark, by my ingenious and worthy friend, Lieutenant Fairlamb, of the Artillery; who informs me, that the church of St. Michael, in CHARLES TOWN, South Carolina, used to be struck and damaged by lightning, in every two or three years from its first erection; but in fourteen years, that it hath been furnished with a pointed conductor, it hath never been struck at all. It appears also, that when a stroke of

lightning fell upon a stable belonging to WILLIAM LYTTLETON Esquire, Governor of South Carolina, and split and threw down two of the rafters ; yet the dwelling house, at twenty yards distance, being provided with a conductor, terminated by a sharp point, escaped unhurt. I would here also just remark, that nothing can be more sharply pointed, than the weather-vane which terminates the conductor, * on one of the pinnacles on the tower of St. MICHAEL'S church in CORNHILL, which consists of two darts, with a star, having many pointed radii between them ; yet in the late thunder storm, the lightning does not appear to have struck this building ; but fell upon the key, at the top of the spire of St. PETER'S church, which is considerably lower than the vane of St. MICHAEL'S ; and the distance of the two churches is not more than two hundred feet ; as I have been informed by Mr. EDWARD NAIRNE who measured it. This key is terminated by a thick blunted end : the spire is covered with lead, from the key to the brick tower ; and so far the lightning was conducted with safety to the building ; nor could I observe, that there had been the least fusion upon the metal ; some parts of it, however, I could not get at to examine ; but having quitted the lead work, and entered the brick tower, it there did considerable damage, till it reached the leaded roof on the body of the church ; whence it seems to have been conducted, by the pipes, which carry down the rain water, and which reach to the bottom of the building, without further damage.

* Erected by my ingenious friend MR. EDWARD NAIRNE.

Almost at the same instant that this spire was struck, the lightning fell also upon a Dutch ship, in the river Thames, lying off the Tower, which had an iron spindle, terminated by a thick blunted end, at her mast-head, and did her much damage. A very exact account of which hath been taken by Mr. BELL, and, at another opportunity, will be laid before the members of this Society.

The lightning struck also upon the pillar, commonly called the OBELISK, in the cross road in St. George's-fields, Southwark; a very curious observation of which was made, soon after the stroke, by Mr. Coventry, and Mr. Thomas Green, well known to many in the Royal Society, for his singular and very curious method of preserving the subjects of natural history. It likewise struck the chimney of the new Bridewell there, which it threw down to the ridge of that building, which was covered with lead; and then dispersed itself with little damage. The lightning fell likewise upon another chimney, at LAMBETH; and upon a house at the Physick-garden, near VAUXHALL; and, as before observed, it appears by the best information, nearly at the same time; and in many other places, considerably distant from each other.

I have observed, on another occasion, that if a round ball of metal, two inches in diameter, was presented towards the large prime conductor to a good cylinder, at the distance of two inches, it would continue to receive such strong sparks, as would give the person who held it, a sensible shock in both his legs; but that if the point of a lancet, or a wire six inches long, nicely tapered to a point, and tipped with steel, were, at the same

time, held towards the conductor, at the distance of two feet, the point would draw off all the electricity of it silently, and not suffer a spark to pass from thence to the ball; and from this experiment I inferred, that a sharp point might probably, in some measure, produce the same effect on a cloud highly charged with electricity, * and thus perhaps contribute to lessen a little, if not actually prevent, a stroke. I also observed, that if the point of the wire, or lancet, was brought nearly into contact with the prime conductor; yet no sensation would be felt in the hand of the operator; and this, I imagined, was a kind of demonstration, that there could be no danger of inviting a stroke of lightning from a cloud, by a sharp pointed conductor; as it could make no difference in the experiment, whether the point moved towards the large prime conductor, or the conductor moved towards the point. It having, however, been objected to this experiment, that it was not analogous to the effect of nature operating by a cloud; forasmuch as the cloud being a loose and floating body, it might accede to, and strike upon the point with its contents; which the conductor, being a fixed body, was incapable of doing, I made the following experiment.

EXPERIMENT VII.

I procured, by means of my ingenious friend Mr. Coventry, a bullock's bladder, of the largest size; which bladder Mr. Coventry gilded for me with leaf copper, and suspended it, by a silken

* Or rather on the electric atmosphere, surrounding the cloud.
string,

string, at one end of an arm of wood, placed horizontally, and turning freely upon the point of a needle; the needle being stuck upright in another piece of wood, inserted in a firm base, and standing in a perpendicular direction to the floor. The bladder was balanced by a leaden weight, at the other end of the wooden arm, see Fig. 7. The apparatus being thus adjusted, I gave the bladder a strong spark, from the knob of a charged bottle; when, presenting towards it a brass rod, terminated by a ball, two inches in diameter, I observed, that the bladder would come towards it, at the distance of three inches; it would even come back to it, when swinging in a contrary direction; and when it had got within one inch of it, it would throw off its electricity in a full and strong spark: the bladder gave the spark nearly, if not quite, as large as it received it. I then gave it another strong spark, as before, when, presenting towards it the pointed wire above-mentioned, I could never perceive that it acceded to that; and when it was brought nearly into contact with the bladder, there was no spark at all, scarce any sensible quantity of electricity remaining in it. I repeated the experiments many times, with the utmost care and accuracy I was able; and always with the very same result.

To the observations I have now made, upon the different effects of sharp pointed wires, or those terminated by blunted ends, or round balls, in electrical experiments, I shall add another, with which I have lately been favoured by THOMAS RONAYNE Esquire, whose permission I have to insert it in this paper.

Having

Having cut off a few inches of small harpsichord-wire, he connected one end of it with the the loop, at the bottom of his electrical battery, consisting of nine bottles; the other end of the wire he fastened to his discharging rod, which was terminated by a large round ball. Upon this ball he took the charge of his battery, when the whole of the small wire was instantly melted. He then cut off another piece, of equal length with the former; and, unscrewing the ball, he fixed the small wire in its stead, upon the upper end of his discharging rod. The lower end of the rod was now in contact with the bottom of the battery. The apparatus being thus disposed, he re-charged the battery, and took off the charge upon the end of the small wire, which was sharply pointed; but, in this case, only a very little of the wire was melted; proving, as he observes, the preference due to points rather than knobs, as terminations to the conductors for the lightning on buildings, ships, &c. The same gentleman hath lately favoured me with the following experiment, and the inference resulting from it.

“ Having charged a battery, and unscrewed one
 “ of the knobs of the discharging rod, I cemented
 “ a very small portion of leaf gold on that end,
 “ in such a manner as to act like a point; then ap-
 “ plying the other end, or knob, so as to commu-
 “ nicate with the coatings of the jars, I suddenly
 “ brought the gold-leaf, as near the discharging
 “ part of the battery, as could be done without
 “ danger of a stroke; still advancing nearer, in
 “ proportion to the descent of the index of your
 “ elec-

“electrometer. In this manner, I exhausted the
 “battery, without any sensible diminution, or de-
 “struction, of the gold leaf. Whereas a greater
 “quantity of leaf gold may be dissipated, by a
 “stroke from a single small jar, if put under one
 “of the knobs of the discharging rod, and the
 “stroke be invited by the other; for in such case,
 “the leaf gold cannot, in any manner, act like a
 “point.

“Now as bodies act at a greater distance, by
 “how much they are more acute, and thereby
 “diminish any known electrical force; and, as in
 “any particular case, the smallness of the pencil,
 “or stroke, depends on the acuteness of the point
 “presented, I cannot avoid giving my suffrage
 “for points, in preference to obtuse bodies.

It may not, I think, be improper to introduce,
 in this place, an experiment lately made by Mr.
 EDWARD NAIRNE, in Cornhill; which, though it
 doth not immediately relate to the particular
 subject of this paper, is a very proper one to de-
 monstrate the utility of metallic conductors in
 general.

MR. NAIRNE'S EXPERIMENT.

He affixes, in a little apparatus resembling
 the hulk of a ship, a glass tube, about eight
 inches long, and half an inch in diameter, which
 is to represent the main-mast. The ends of the
 tube, which is filled with water, are properly se-
 cured by corks; and, through each cork, a wire
 is introduced, of such a length as to reach nearly

to

to the middle of the tube, and leave a distance of about half an inch, between the ends of the two: as in a curious experiment of Mr. LANE's, made with small phials. A slight shock, discharged through this apparatus, instantly breaks the tube in pieces, at that part, where the electric matter quits the upper wire, and expands itself in the water, before it reaches the lower one; as the natural electricity hath been observed to do, in bodies, wherein it hath met with such an interrupted and broken communication of metal; but Mr. NAIRNE having fixed, at the top of such a glass tube, and united with the wire of it, a piece of very small harpsichord wire, which was continued to the bottom of it, and there fastened to a regular communication of metal, in contact with the coating of the jars; he discharged through it his four batteries united, consisting of sixty-four jars, containing fifty square feet of coated surface fully charged, when the whole of the small wire was instantly exploded and lost; but the tube remained unhurt. An effect analogous to that of the natural electricity, where, though it hath sometimes happened, that the conductor, being too small, hath been in part destroyed, or much injured by a stroke; yet the building, to which such a conductor hath been affixed, hath escaped, without receiving the least damage.

Among some very interesting remarks on the effects of lightning, by the ingenious Professor WINTHROP of NEW CAMBRIDGE, which have lately been communicated to me by my learned friend Dr. FRANKLIN, I find one, on the influence

of

of sharp pointed conductors, so immediately relating to the question under consideration, that no apology will be necessary for introducing it in this place. Dr. WINTHROP, having given a very curious and exact account of a violent flash of lightning, which fell upon and greatly damaged HOLLIS-HALL, in NEW CAMBRIDGE, observes, that HARVARD-HALL, being furnished with pointed wires, which wires were at the distance of one hundred and sixty feet from the chimney of Hollis-hall, on which the lightning fell, escaped unhurt, though the wires were seen by many to transmit a large quantity of it, which left visible marks upon the bricks, where the wire hooked together. This gentleman also observes, that a tree, standing at the distance of fifty-two feet from a pointed wire, erected upon the steeple of a meeting-house, as a conductor for the lightning, had been struck and shivered; but that the meeting-house remained uninjured; and this, he says, is the least distance from such a conductor, so far as he knew, at which any thing had been struck by lightning. It appears, therefore, I think, very clearly, from these instances, that sharp pointed wires, instead of inviting, and drawing down strokes of lightning, serve rather to prevent them, and that they extend their protecting influence to some distance around them, and ought therefore ever to be used, as the termination of the rods erected upon houses, steeples, magazines, masts of ships, &c. in short, on all occasions, where conductors for the lightning may be thought necessary.

I cannot avoid taking notice, in this place, of some appearances, upon the iron conductors on St. PAUL's cathedral, supposed to have been the effects of lightning; of which an account hath been given to the Royal Society, by a very ingenious and worthy member, of whose candor I would willingly think too highly, to suppose he can be offended, if my opinion concerning these appearances should be different from his. In the first place, had those bars been heated to a red heat so instantaneously, it seems probable, that the moisture in the stone, which almost surrounds a considerable length of them, at each end, where they are inserted in the pavement, would have been turned to steam; and, acting like gun-powder, would have exploded, and driven out the bars with great violence. Also the leaden pipes, particularly the ends of them which are in contact with the iron bars, must have been much melted; but these I carefully examined, and could not perceive, that they had been at all affected. Secondly, the end of the iron bar, supposed to be the most affected, was not in contact with the lead-work below it, by near two inches; yet it had no appearance of fusion, as it certainly would have had, if so large a quantity of electricity had passed through it; the rust likewise, I think, would have been cleared away, which was not the case, and the end of it have been left quite bright. As to the hole through the dirt, (mentioned by Mr. Gould,) which lay adjoining to it; the dirt lying in a perpendicular direction, I am inclined to think, that the rain-water had soaked through it, and not washed it

it intirely away. I should apprehend likewise, that the rust observed to lie upon the pavement, had been beaten off from the bars, by the hail, or washed off, by the rain, which could not happen to the end of that before mentioned; it being covered by a stone, which compleatly sheltered it from the weather. Had it been exploded from the bars, by so violent a stroke of lightning, as hath been supposed to pass through them, I have some doubt, whether much of it, if any, would have been discovered. Thirdly, in so great a stroke, the pointed ornaments of copper, upon the crosses, would probably have been affected; perhaps melted down; but these do not appear to have received the least injury. I must further remark, that as the conductors, on which these appearances were observed, were neither of them in contact with the lead-work below them; and there were two other conductors of equal size, forming a regular communication of metal throughout; it seems probable, that the electricity would have passed in the two last mentioned; and that those supposed to be so much affected, would have conducted very little, if indeed any part at all of the shock. The improbability, I believe I might venture to say the impossibility, of those bars, which are four inches broad and half an inch thick, being heated to a red heat, by lightning, appears to me still more plainly, when I consider, that in a stroke, which fell upon the weather vane in the spire of St. BRIDE's church, in Fleet-street, the iron spindle, which supported it, being twenty feet long, and two inches in diameter, and the lower ten

feet of it being furrounded by stone work, and fixed firmly therein by melted lead, was not in the least affected ; but conducted the stroke, as far as it went, with safety to itself as well as the building ; and no doubt would have done the same to the bottom, had it been continued thither. In this bar, the lightning had an opportunity of accumulating, and it appears, that it did so, to a most astonishing degree ; yet the gilding only, on the fane, was a little discoloured, owing perhaps to the gold size, which connected it with the metal ; and this, it seems, was all the damage it sustained. Similar to this, I would observe, that the paint, on several parts of the iron-work, now in my possession, of the chapel, through which the lightning hath passed, is not at all affected. An iron bar also, upon the OBELISK before-mentioned, of ~~about half an inch~~ ^{1/4} diameter, which supports the lamp iron at the N. W. corner, upon which the lightning concentrated ; and two of the iron rails, on which it leaped from thence, are not injured in the painting ; though the points of the rails, which were the fourth on the N. and the fifth on the W. side, and the two corners of the iron bar, from whence it flew upon them, were melted a little. It is worthy notice, that these two rails were the nearest to, and stood at nearly an equal distance, about twenty-five inches, from the lower end of the bar before-mentioned. In short, the more I reflect on this remarkable account, and consider the effects of lightning in former and similar instances, the more firmly I find myself fixed in my opinion, that the appearances, observed
upon

upon the conductors on St. PAUL's cathedral, were not the effects of lightning, but proceeded from very different causes.

I have made many other experiments on the different effect of knobs or points, as opposed to insulated electrified bodies; but as they all concur, in establishing and confirming the opinions before advanced, it seems unnecessary to mention them; and the more so, as I believe those already recited will be deemed sufficiently decisive without them.

Having now finished what I had to offer, upon the subject of pointed conductors, as being the most proper for the security of buildings, &c. I shall add, by way of appendix, a very curious observation, relating to *personal* security, which I find likewise among those of the learned Professor WINTHROP, communicated to me by Dr. FRANKLIN. This gentleman, having remarked, that people standing in an open plain, are by no means secure from a stroke of lightning, advises those, who may be overtaken by a storm, in such a situation, to retire within some small distance, as from thirty or forty, to ten or fifteen feet, of an high tree (perhaps about fifteen or twenty feet from the outermost branches, may be as proper a distance as any) or rather two such, if at hand, and there wait the event, but by no means to go under them. This advice will, I believe, be acknowledged to be most judicious, and, if properly attended to, may be of great service.

service to travellers, and be the means of saving the lives of numbers; and as such, cannot be made too public.

P. S. Since the reading of the preceeding paper, I have taken an opportunity to repeat the most interesting of the experiments therein recited; and find no reason to alter a tittle in my account of them.

The 6th experiment I have also varied a little, as follows; I placed the large copper ball, C, at such a distance from that in contact with the jars, that on bringing down the charge by my discharging rod, it seemed to remain almost undiminished, though the rod was kept in contact with the prime conductor a full minute. Then, repeating the experiment, with a point instead of a knob, the charge was, in a great measure, presently drawn off silently. Upon the whole, it appears that though a sharp point will draw off a charge of electricity silently, at a much greater distance than a knob, yet a knob will be struck with a full explosion, or shock, the charge being the same in both cases, at a greater distance than a sharp point; and this, I imagine, completely decides the question, which I proposed to examine.

F I N I S.

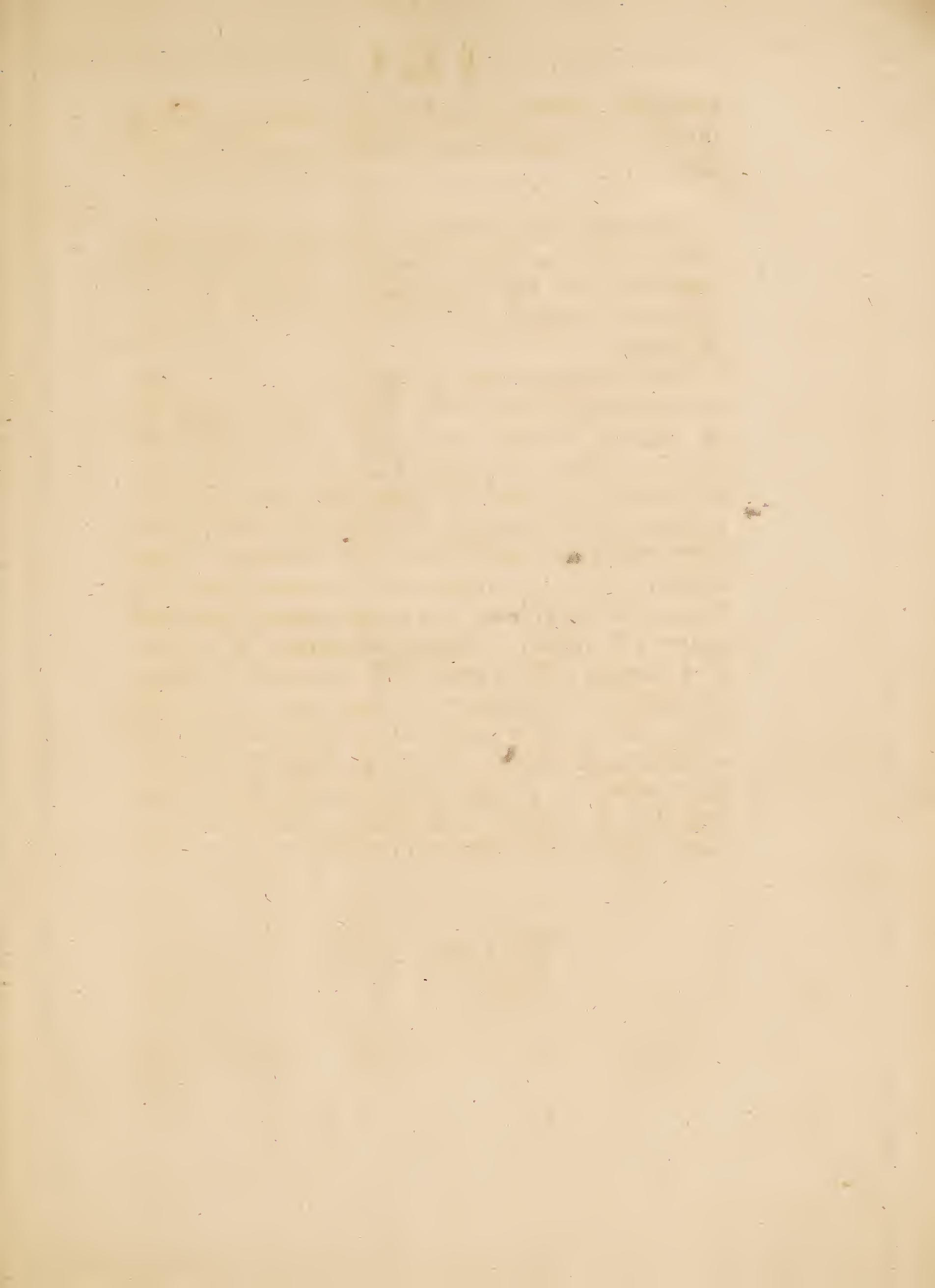


Fig. 1.

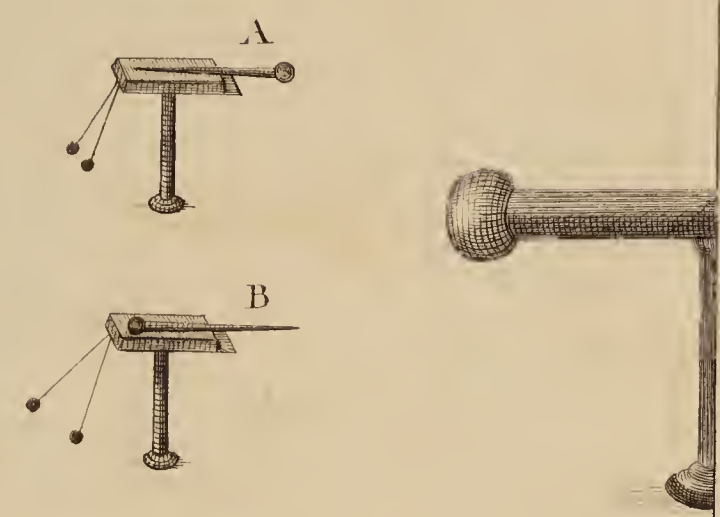


Fig. 2.

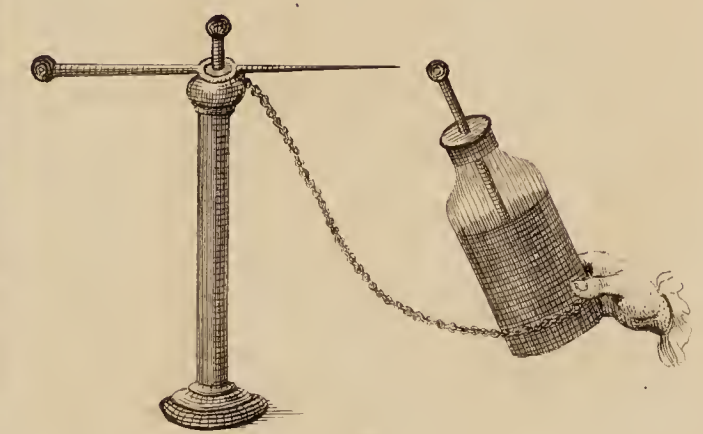


Fig. 3.

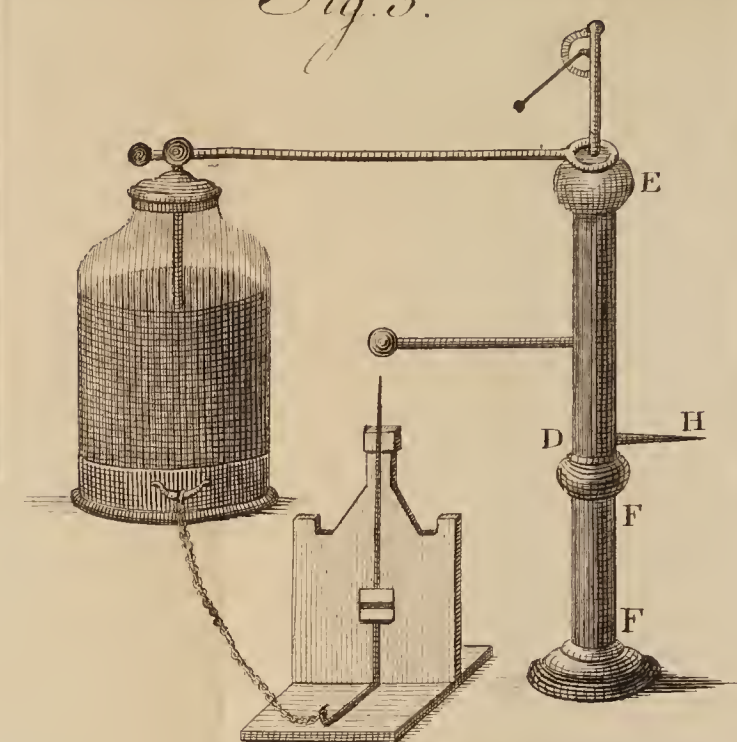


Fig. 4.

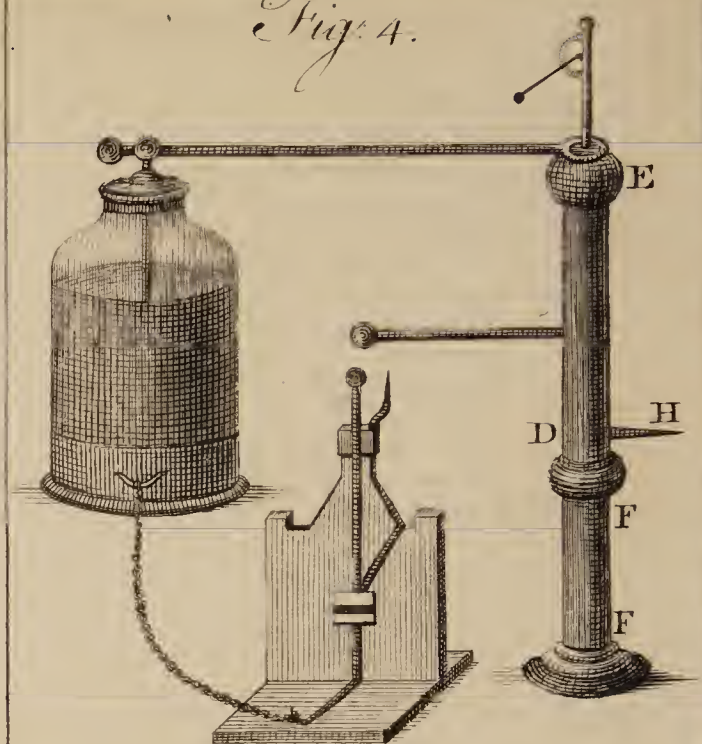


Fig. 5.

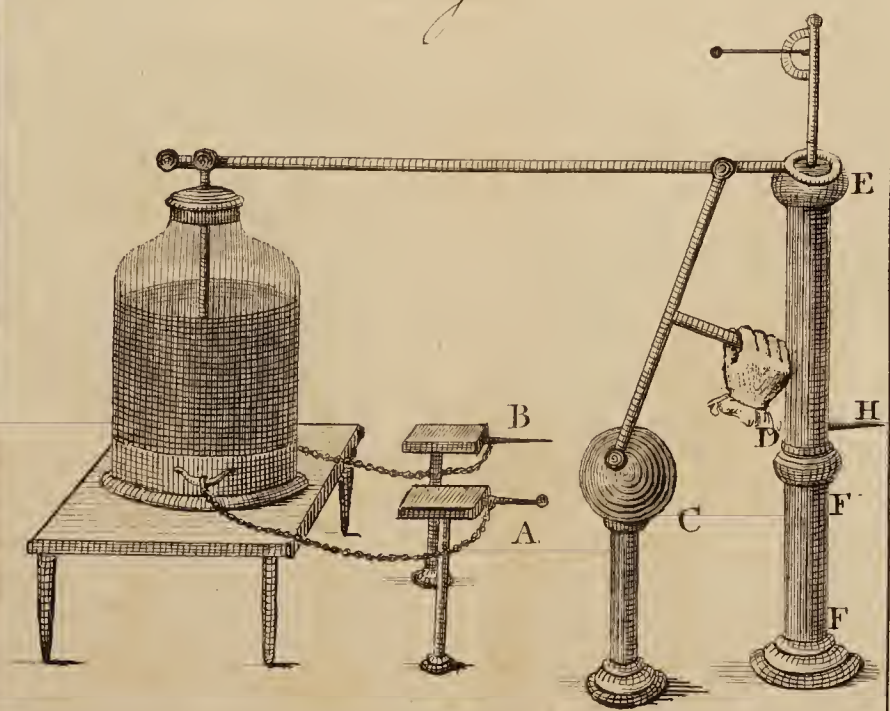


Fig. 6.

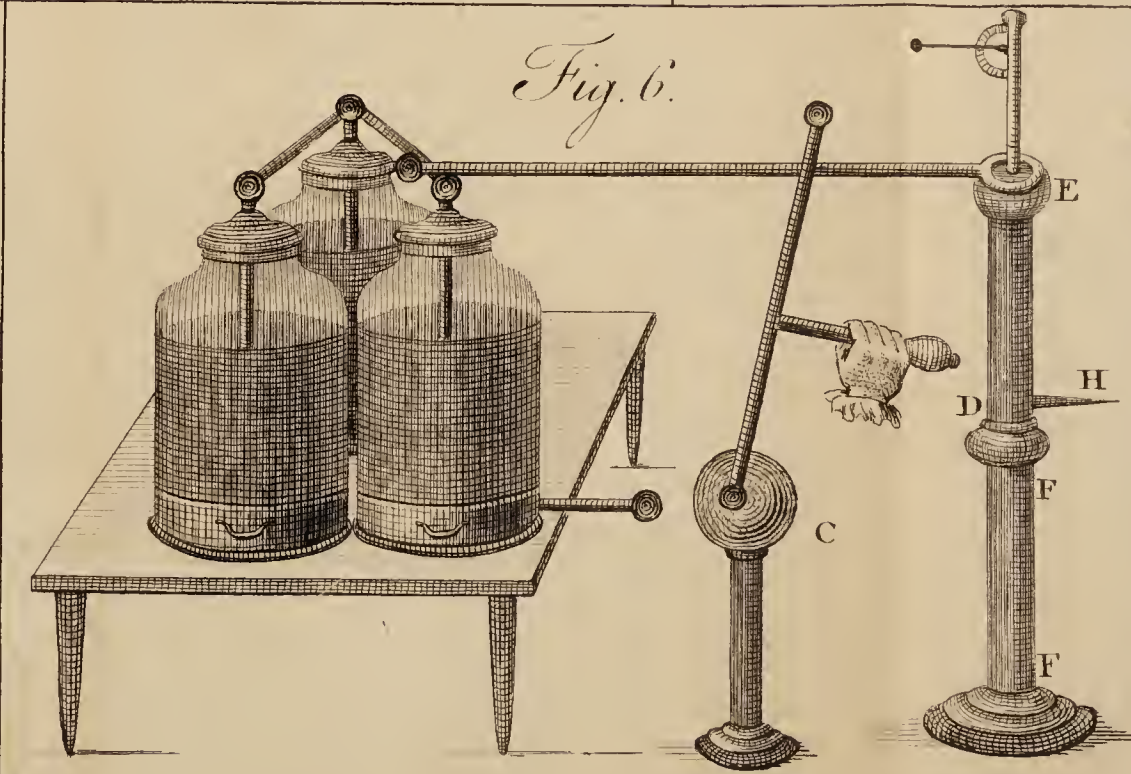
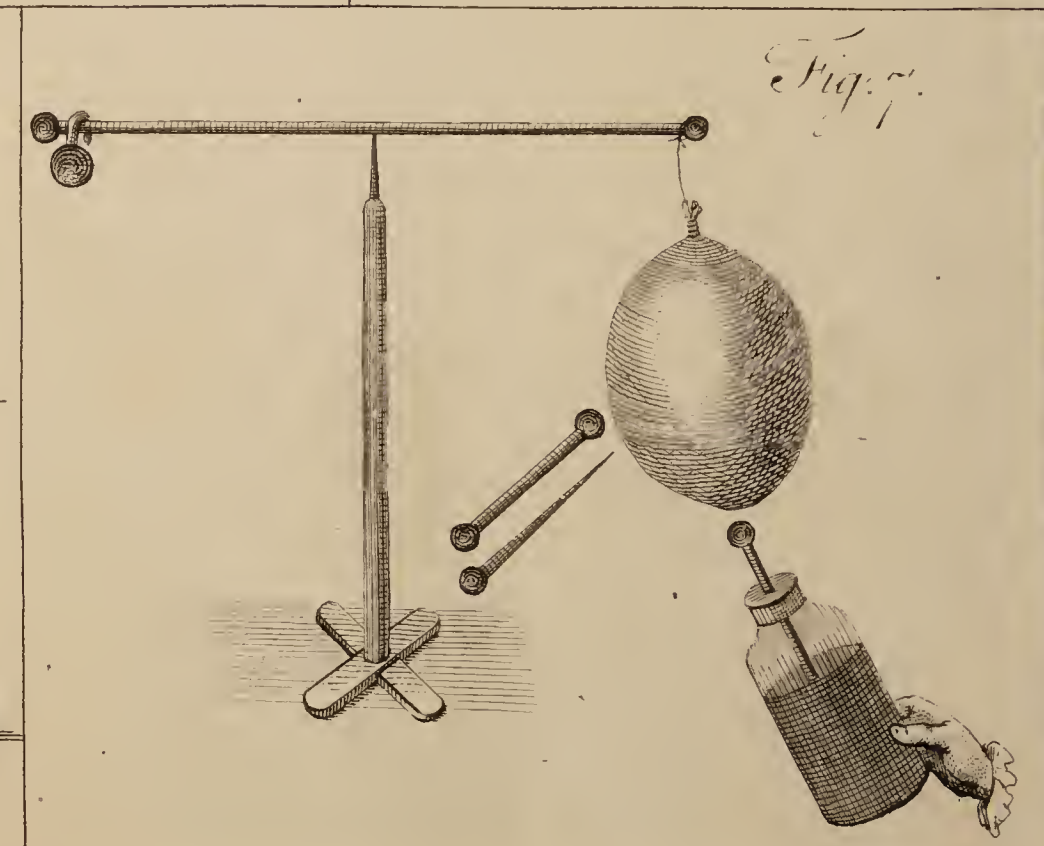


Fig. 7.



D.F. Fig. 3 & 5. 6 is the prime conductor which is supported on a Glass Rod F.F. The point H. draws off the Electricity from the excited Globe, which is not shown in these figures.

Baure etc.

